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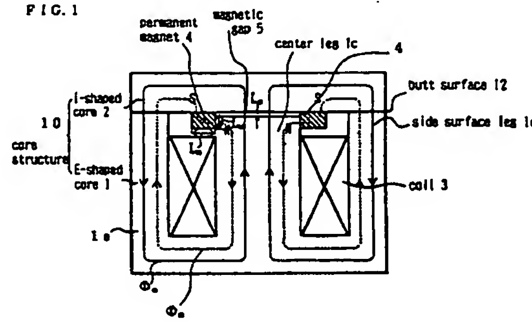
(54) D.C. REACTOR

(57) A D.C. reactor comprising a core structure having two opposed cores separated by a magnetic gap, to form a closed magnetic circuit; a coil would on one or both of the cores; a pair of permanent magnets for biasing, disposed on the core structure; magnetic flux generation means for causing the bias flux generated by the permanent magnets and the flux generated by the coils to flow in opposite directions; and bypass means for causing the bias flux generated by the permanent magnets to bypass the magnetic gap. The core structure comprises an E-shaped core and an I-shaped core, the magnetic gap is defined between a center leg of the E-shaped core and the I-shaped core, the coil is wound on the center leg of the E-shaped core, and each permanent magnet is shaped into a rectangle and disposed one both side surfaces of the center leg of the E-shaped core. The permanent magnet is a sheet-like permanent magnet magnetized so that each of its longitudinal direction and the direction of thickness forms two poles on each side, and the neutral line of this permanent magnet is brought into conformity with the center line of the magnetic gap and is disposed on both outer side surfaces of the core structure. Since the flux generated by the D.C. reactor does not pass inside the permanent magnet, an eddy current loss decreases, and even when a large current abruptly flows through the coil, the permanent magnet is not demagnetized.

FIG. 1



EP 0 744 757 A1

Description

[Technical Field]

The present invention relates to a D.C. reactor in which, since flux generated by the D.C. reactor does not pass inside the permanent magnet, an eddy current loss decreases, and even when a large current abruptly flows through the coil, the permanent magnet is not demagnetized, said reactors being capable of using low-cost permanent magnets of lower coercive force than the SmCo-system, such as the Nd-Fe-B system. The invention also relates to D.C. reactors capable of decreasing the core cross-sectional area and suitable for down-sizing, wherein the magnetic flux may decrease inside the core due to mutual cancellation of a bias magnetic flux formed by permanent magnets and a magnetic flux formed by the coil which are in opposite directions.

[Background Art]

Conventional, so-called D.C. reactors make use of permanent magnets to provide magnetic biassing. As one such reactor, there is proposed a D.C. reactor employing an E-shaped core and an I-shaped core, wherein the E-shaped core has a center leg on which a coil is wound and which is lower than side legs, and wherein the side legs are bridged by the I-shaped core while causing permanent magnets to provide magnetic bias to be disposed in a magnetic gap between the center leg of E-shaped core and the I-shaped core. Such an arrangement has been disclosed in, for example, Japanese Patent Publication No. Sho 46-37128. However, with this type of D.C. reactor, since the magnets are inserted into the gap, a specific magnetic material must be employed which will exhibit no demagnetization upon application of the magnetic flux formed by the coil. Also, while the inductance of the D.C. reactor becomes greater as the gap is reduced, a reduced gap renders the magnet thinner, impeding fabrication and causing demagnetization to occur more frequently. Accordingly, it should be strictly required that the magnet be thicker as long as there is some possibility of a large current. This may increase the resulting gap, also increasing the cross- sectional area of the core, and necessitating a larger reactor. Another disadvantage encountered with the prior art reactors is that, when high coercive-force magnets such as rare earth magnets are used to eliminate demagnetization, an increased eddy current may take place inside the magnet due to the small inherent resistance thereof.

One improved D.C. reactor is disclosed in Unexamined Japanese Patent Publication No. Sho 50-30047, wherein the permanent magnet of the aforesaid D.C. reactor consists of a plurality of permanent magnets. With this D.C. reactor, however, while the problem concerning the eddy current loss may be solved, the demagnetization problem remains unsolved, thus increasing manufacturing costs due to the assembly of the plurality of permanent magnets.

A further improved D.C. reactor has been disclosed in Unexamined Japanese Patent Publication No. Hei 4-84405. This reactor comes with an energizing coil provided on the center leg of an E-shaped core of an EI-shaped core, a gap defined between respective tip portions of the center leg and both legs of the E-shaped core and an I-shaped core, magnetically biased permanent magnets which are arranged at respective outer surfaces of the E-shaped core and magnetized along the thickness thereof in such a manner that their opposed portions are of opposed polarity, and a yoke provided on the outer surface of each permanent magnet to be in contact with a corresponding edge of the I-shaped core. With this kind of D.C. reactor, since the magnetic flux formed by the coil does not flow inside the permanent magnets, demagnetization will no longer take place. However, the reactor suffers from another problem in that the magnetic flux formed by the permanent magnets and the magnetic flux formed by the coil are such that they extend in the same direction on either the right or left side of the E-shaped core while they extend in opposite directions on the other side, thus causing the nearby core in the same direction to be easily saturated.

Accordingly, an object of the present invention is to provide a D.C. reactor capable of avoiding the disadvantages of the prior art, which can also eliminate demagnetization of permanent magnets, suppress the occurrence of saturation of any magnetic flux inside the core, and reduce the size and manufacturing costs thereof.

[Disclosure of Invention]

According to the present invention, a D.C. reactor includes a core structure having two opposing cores with a magnetic gap being defined therebetween to form a closed magnetic circuit, a coil wound on one or both of the cores of said core structure, and a pair of biassing permanent magnets provided on said core structure, the improvement comprising magnetic flux generation means for causing the bias flux induced by said permanent magnets and the magnetic flux created by said coil to flow in opposite directions, and bypass means for forcing the bias flux created by said permanent magnets to bypass said magnetic gap. Furthermore, the core structure comprises an E-shaped core and an I-shaped core, wherein said magnetic gap is defined between the center leg of the E-shaped core and the I-shaped core, said coil is wound on or around the center leg of said E-shaped core, and said permanent magnets are formed into a rectangular shape and provided at the both sides of the center leg of said E-shaped core. With such an arrangement, the magnetic flux induced by the coil and the magnetic flux formed by the permanent magnets are diverted in the magnetic

gap, enabling the D.C. reactor to eliminate demagnetization in the permanent magnets.

In accordance with another aspect of the present invention, the permanent magnets of the improved D.C. reactor mentioned above are each constituted from a plate-shaped permanent magnet, magnetized so that each of its longitudinal directions and the direction of thickness form two poles on each side, while the neutral line of this permanent magnet is brought into conformity with the center line of the magnetic gap and is disposed on the both outer surfaces of the core structure. With such an arrangement, since the magnetic flux created by the coil does not pass through the inside of permanent magnet, the permanent magnet will no longer be demagnetized, while forcing the bias magnetic flux formed by the permanent magnet and the magnetic flux created by the coil to be in opposite directions and thus be cancelled out with the result of the magnetic flux being decreased inside the core, which may enable the core to have a decreased cross-sectional area as compared with a core where no biassing magnets are used.

[Brief Description of the Drawings]

Fig. 1 is a diagram showing a principal cross-sectional view of a D.C. reactor in accordance with a first embodiment of the present invention, Fig. 2 is a diagram showing a principal cross-sectional view of a D.C. reactor in accordance with a second embodiment of the invention, Fig. 3 is a diagram showing a principal cross-sectional view of a D.C. reactor in accordance with a third embodiment of the invention, Fig. 4 is a diagram showing a principal cross- sectional view of a D.C. reactor in accordance with a fourth embodiment of the invention, Fig. 5 is a diagram showing a principal cross-sectional view of a D.C. reactor in accordance with a fifth embodiment of the invention, Fig. 6 is a diagram showing a principal cross-sectional view of a D.C. reactor in accordance with a sixth embodiment of the invention, Fig. 7 is a diagram showing a principal cross-sectional view of a D.C. reactor in accordance with a seventh embodiment of the invention, Fig. 8 is a diagram showing a principal cross-sectional view of a D.C. reactor in accordance with an eighth embodiment of the invention, and Fig. 9 is a diagram showing a principal cross-sectional view of a D.C. reactor in accordance with a ninth embodiment of the invention.

[Best Mode for Carrying Out the Invention]

The present invention will be described with reference to the accompanying drawings. Fig. 1 shows a principal cross-sectional view of a D.C. reactor in accordance with the first embodiment of the present invention. An E-shaped core 1, made of a chosen soft magnetic material, and an I-shaped core comprised of a magnetic material are combined on a butt plane 12 to constitute an EI-shaped core structure 10. The reactor shown is similar to the prior art in that a center leg 1c of the E-shaped core is shorter than the outer side legs 1e thereof defining a magnetic gap 5 therebetween in order to attain a desired value of inductance. Note here that a very thin insulator sheet may be inserted into butt plane 12 for elimination of vibration. Two rectangular permanent magnets 4 having a width determined to provide a predefined biased magnetic flux are arranged on both sides of a certain portion of center leg 1c where magnetic gap 5 is formed, in such a manner that these magnets are anisotropically magnetized causing the contacted portions to of differing polarity from each other. These permanent magnets are specifically disposed so that they are parallel with I-shaped core 2, while allowing their same polarity portions to oppose each other with the center leg 1c being interposed therebetween. In this embodiment the N pole sections of permanent magnets 4 are disposed on opposite sides of center leg 1c as shown. The width Lw of each permanent magnet 4 is determined relative to the length Lg of magnetic gap 5 to satisfy $Lw >> Lg$, thus enabling accomplishment of the desired magnetic biassing effect. The thickness Lm of the permanent magnets 4 is suitably determined by taking into account the field of demagnetization that may occur due to leakage flux of coil 3. A coil 3 is wound on or around center leg 1c, allowing magnetic flux ϕe induced by the coil 3 to extend from the center leg 1c toward the magnetic gap 5. Hence, the magnetic flux ϕe formed by the coil 3 and biased magnetic flux ϕm created by the permanent magnets 4 are opposite in directions. Permanent magnet pair 4 and coil 3 constitute a magnetic flux generation means for causing the magnetic flux formed by each of them to flow inside core structure 10 in opposite directions. In this case, the magnetic flux created by permanent magnets 4 in magnetic gap 5 flows inside permanent magnets 4 to bypass magnetic gap 5. Note that coil 3 may alternatively be wound on both side legs 1e. Note also that permanent magnets 4 are not exclusively limited to a rectangular shape; they may alternatively be either ring shaped or a rectangularly solid shape having a center opening that is engageable with center leg 1c.

The operation is as follows. When coil 3 is magnetically excited or magnetized by a pulsating D.C. current supplied thereto, it creates magnetic flux ϕe, which extends from the center leg 1c of E-shaped core 1 and penetrates magnetic gap 5 to be diverted or divided at the center of I-shaped core 2 into right and left components, each of which passes through butt plane 12 to return to center leg 1c by way of one of side legs 1e, as indicated by the solid line in the drawing. On the other hand, as indicated by the broken lines, the bias magnetic flux ϕm created by each permanent magnet 4 extends from center leg 1c to penetrate a corresponding one of side legs 1e, and then enters I-shaped core 2 through butt plane 12, and thereafter returns at the center leg 1c via permanent magnet 4 while it bypasses magnetic gap 5.

Fig. 2 shows a principal cross-sectional view of a second embodiment of the invention. Core structure 10 here is a CT type as constituted from a combination of a C-shaped core 11 and a T-shaped core 21, rather than the E-shaped core 1 and I-shaped core 2 as in the first embodiment. The T-shaped core 21 has a leg portion 21c around which coil 3 is wound. Extremely thin insulator sheets 52 are sandwiched between bottom portions 21b of T-shaped core 21 and tip portions of both side legs 11e of C-shaped core 11. Likewise, a thin insulator material 51 is interposed between the top bar portion of T-shaped core 21 and the central portion of C-shaped core 11. A magnetic gap 5 is defined between leg 21c of T-shaped core 21 and the center of C-shaped core 11. A pair of permanent magnets 4 for generating biased magnetic flux are provided on opposite sides of magnetic gap 5 so that their opposed portions have the same polarity. With such an arrangement, the manufacture of coil windings can be easier than that in the first embodiment. The operation is substantially the same as that of the first embodiment, and therefore its explanation will be omitted herein.

Fig. 3 is a diagram showing a principal cross-sectional view of a third embodiment of the invention. This embodiment is arranged to replace permanent magnets 4 of the first and second embodiments with 1/4-circular permanent magnets 41. These permanent magnets 41 may alternatively be formed into a right triangular shape.

Fig. 4 is a diagram showing a principal cross-sectional view of a fourth embodiment of the invention. This example is similar to the second embodiment with magnetic gap 5 being modified to be defined between both bottom portions 21b of T-shaped core 21 and both ends of side legs 11e of C-shaped core 11. Permanent magnets 4 are disposed at both ends of the bar portion of T-shaped core 21 so that the bottom of each magnet 4 is above magnetic gap 5, while causing the opposed portions thereof to have the same polarity. Each permanent magnet 4 has a back surface on which a back yoke 6 is arranged to bridge the outer surface of each magnet 4 and a corresponding one on the outer surface of C-shaped core 11. The back yoke 6 has an L-shape that defines at its upper portion a recess 6d having a depth equivalent to the thickness of permanent magnet 4 associated therewith, thereby allowing magnet 4 to be held within recess 6d while the lower portion of the L-shaped yoke is secured to a corresponding side surface of C-shaped core 11 coupled therewith. Note that back yokes 6 may be formed integrally with C-shaped core 11 by known die-cut or punch-through fabrication techniques. In this embodiment the magnetic flux ϕm formed by each permanent magnet 4 extends from its associative back yoke 6 to penetrate magnet 4, and bypasses magnetic gap 5 through which the magnetic flux ϕe created by coil 3 passes.

It should be noted that permanent magnets 4 may alternatively be arranged on opposite sides of C-shaped core 11; in this case, magnets 4 are disposed so that the bottom surfaces underlie magnetic gap 5 while back yokes 6b are provided on the both outer surfaces of T-shaped core 21.

Fig. 5 is a diagram showing a principal cross-sectional view of a fifth embodiment of the invention. An I-shaped core 2 is provided above an E-shaped core 1 constituting an EI-shaped core structure 10. E-shaped core 1 has a center leg 1c around which a coil 3 is wound. At the top portions of center leg 1c and side legs 1e, center leg 1c is arranged to be higher than side legs 1e. A very thin insulator sheet 52 for elimination of vibration is interposed between center leg 1c and core 2; a thin insulator material 51 is sandwiched between each side leg 1e and I-shaped core 2. After assembly of the E-shaped core 1, I-shaped core 2, insulator sheet 52 and insulator materials 51, a pair of permanent magnets 4a for generating a plate-like biased magnetic flux is disposed on both outer surfaces of a pair of magnetic gaps 5 as formed between side legs 1e of E-shaped core 1 and I-shaped core 2 in such a manner that magnets 4a are magnetized to have two poles on each side in the longitudinal direction of the plate and in the direction of thickness thereof causing the opposed portions to be identical in polarity while forcing the neutral line Cm -- whereat the N pole and S pole are replaced with each other -- to be identical with the center line Cg of magnetic gaps 5. The pair of permanent magnets 4a and coil 3 may constitute a magnetic flux generation means. Provided on the back surfaces of permanent magnets 4a are plate-shaped back yokes 6 which consist of a pair of magnetic materials.

The operation is as follows. When coil 3 is excited and magnetized by a pulsating D.C. current, the magnetic flux ϕe formed by coil 3 extends from center leg 1c and pass along a magnetic path consisting of I-shaped core 2, side legs 1e and the bottom portion of E-shaped core 1, as shown by solid lines in the drawing. On the other hand, the biased magnetic flux ϕm created by each permanent magnet 4a extends from I-shaped core 2 and passes along a magnetic path as formed by center leg 1c, bottom portion of E-shaped core 1, one corresponding side leg 1e associated therewith, one corresponding permanent magnet 4a and its associated back yoke 6. More specifically, inside E-shaped core 1 and I-shaped core 2, magnetic flux ϕe formed by the coil 3 and biased magnetic flux ϕm created by permanent magnets 4a flow in opposite directions, while biased magnetic flux ϕm created by permanent magnets 4a bypasses the magnetic flux ϕe formed by coil 3 at the right and left magnetic gaps 5. Since the magnetic flux ϕe formed by coil 3 does not penetrate the inside of permanent magnets 4a, permanent magnets 4a will not be demagnetized; furthermore, because the biased magnetic flux ϕm created by permanent magnets 4a and the magnetic flux ϕe formed by the coil 3 are cancelled out with each other due to their reverse directions, any magnetic flux inside the core will decrease, enabling a smaller cross-sectional area of the core than would be possible were there no bias magnetic flux.

Fig. 6 is a diagram showing a principal cross-sectional view of a sixth embodiment of the invention. E-shaped core 1 of the fifth embodiment is replaced with a C-shaped core 11, while I-shaped core 2 thereof is replaced by a T-shaped core 21, thereby constituting a CT-shaped core structure 10. A coil 3 is wound on a leg 21c of T-shaped core 21. A very thin insulator sheet 52 is interposed between the top portion of leg 21c of T-shaped core 21 and the bottom portion of C-shaped core 11, whereas a thin insulator material 51 is sandwiched between each bottom portion 21b of T-shaped core 21 and its corresponding side leg 11e of C-shaped core 11 associated therewith. A pair of permanent magnets 4a are provided on both outer surfaces of T-shaped core 21 and both legs 11e of C-shaped core 11, at which magnetic gaps 5 are defined, in such a manner that their opposed portions have the same polarity and that the neutral line Cm whereat the N pole and S pole are interchanged is identical to center line Cg of magnetic gaps 5. A Pair of back yokes 6 made of a chosen magnetic material are adhered to the backs of permanent magnets 4a, respectively. The operation may be similar to that of the fifth embodiment, and therefore an explanation thereof will be omitted herein.

Fig. 7 is a diagram showing a principal cross-sectional view of a seventh embodiment of the invention. E-shaped core 1 of the fifth embodiment is replaced with a C-shaped core 11 to provide a CI-shaped core structure as shown. A coil 3 is wound around the center section of I-shaped core 2. A pair of plate-shaped permanent magnets 4a for generating biased magnetic flux are arranged on both outer surfaces of C-shaped core 11 and I-shaped core 2, having magnetic gaps 5 defined there in such a manner that their opposed portions are of differing polarity and that the neutral line Cm at which the N pole and S pole are changed is identical to center line Cm of magnetic gaps 5. Permanent magnets 4a and coil 3 constitute a magnetic flux generation means. Back yokes 6 of a chosen magnetic material are provided on the back surfaces of permanent magnets 4a respectively. The operation thereof is as follows. When coil 3 is magnetized by a pulsating D.C. current fed thereto, the magnetic flux ϕe formed by coil 3 flows through I-shaped core 2, magnetic gaps 5 and C-shaped core 11 as designated by the solid line in the drawing. The magnetic flux ϕm created by each permanent magnet 4a flows inside I-shaped core 2 and C-shaped core 11 in a direction opposite that of the magnetic flux ϕe as shown by the broken line in the drawing, in such a way that the magnetic flux ϕm flows inside permanent magnets 4a and back yokes 6 at magnetic gaps 5 while actually bypassing magnetic gaps 5.

Fig. 8 is a diagram showing a principal cross-sectional view of an eighth embodiment of the invention. The I-shaped core 2 of the seventh embodiment is replaced with a C-shaped core 11 thus providing a pair of C-shaped cores that constitute a core structure 10. Each of these C-shaped cores 11 has a coil 3 wound thereon, forcing the magnetic flux formed by coil 3 to flow in the same direction. A pair of plate-shaped permanent magnets 4a for generating biased magnetic flux are arranged on both outer surfaces of both side legs 11e of C-shaped cores 11 having magnetic gaps 5 defined there in such a manner that their opposed portions are of different polarity and that the neutral line C at which the N pole and S pole of permanent magnets 4a are replaced with each other is identical to center line Cg of magnetic gaps 5. A pair of back yokes 6 of a chosen magnetic material are provided on the back surfaces of permanent magnets 4a. With the arrangements as in the seventh and eighth embodiments, it becomes possible to render the magnetic gaps and the butt planes in a structurally common fashion, reducing the total number of butt planes.

Fig. 9 is a diagram showing a principal cross-sectional view of a ninth embodiment of the invention. This embodiment aims for the reliable position-determination/alignment of each core and permanent magnets of the fifth to eighth embodiments and also for easy attachment thereof. While the description here is directed to the sixth embodiment as an exemplary case, the same principles may also be applied to the remaining ones. Rectangular projections 31p are provided on both sides of T-shaped core 21. Likewise, rectangular projections 11p are formed on the both side surfaces of C-shaped core 11. The distance between the opposed surfaces of one projection 31p and its associated projection 11p is determined to ensure that neutral line Cm of permanent magnets 4a is identical to center line Cg of magnetic gaps 5 after T-shaped core 21 and C-shaped core 11 are assembled together. While individual permanent magnets 4a are set so that each is in contact with the upper surface of a corresponding projection 11p on one of the sides of C-shaped core 11, T-shaped core 21 is vertically inserted between permanent magnets 4a on both sides upward thereof causing neutral line Cm of permanent magnets 4a and center line Cg of magnetic gaps 5 to be set automatically. Note here that permanent magnets 4a employed in the fifth to ninth embodiments may alternatively be arranged so that each consists of two equally subdivided pieces in the longitudinal direction while allowing each piece to be disposed such that the longitudinally opposed portions thereof differ in polarity from each other.

[Industrial Applicability]

As has been apparent from the above description, the D.C. reactors embodying the present invention are adaptable for use in inverter circuits.

Claims

1. A D.C. reactor including a core structure having two opposing cores with a magnetic gap defined therebetween to form a closed magnetic circuit, a coil put on one or both of the cores of said core structure, and a pair of biassing permanent magnets provided

in said core structure, characterized by comprising magnetic flux generation means for causing the biased magnetic flux induced by said permanent magnets and the magnetic flux created by said coil to flow in opposite directions, and means arranged at or near said magnetic gap for causing the biased flux created by said permanent magnets to bypass said magnetic gap.

2. A D.C. reactor as cited in claim 1, wherein said magnetic flux generation means comprises permanent magnets having opposed portions of the same polarity disposed in said core structure, and said coil being wound in a direction allowing magnetic flux to appear in an opposite direction to that of the biased magnetic flux as induced by said permanent magnets.

3. A D.C. reactor as cited in claim 2, wherein said core structure comprises an E-shaped core and an I-shaped core, said magnetic gap being defined between a center leg of said E-shaped core and said I-shaped core, said magnetic flux generation means including rectangular pole-anisotropic permanent magnets with said magnetic flux generation means being provided on both sides of said magnetic gap, and said pole-anisotropic permanent magnets acting also as said means for causing the biased magnetic flux to bypass said magnetic gap.

4. A D.C. reactor as cited in claim 3, wherein said core structure comprises a T-shaped core and a C-shaped core, and wherein said magnetic gap is defined between a leg of the T-shaped core and the C-shaped core.

5. A D.C. reactor as cited in claims 3 or 4, wherein said permanent magnets are 1/4 circles or triangles in shape.

6. A D.C. reactor as cited in claim 2, wherein said means for causing the biased magnetic flux to bypass said magnetic gap comprises said permanent magnets with portions of the same polarity being disposed oppositely on both outer surfaces of said core structure, and back yokes each provided on the back of a corresponding one of said permanent magnets.

7. A D.C. reactor as cited in claim 6, wherein said permanent magnets are provided on both sides of one of said cores of said core structure, and wherein the back yoke bridges the back surface of a corresponding one of said permanent magnets and the outer side surfaces of the other of said cores.

8. A D.C. reactor as cited in claim 6, wherein said permanent magnets include a plate-shaped permanent magnet magnetized so that each its longitudinal direction and direction of thickness each define two poles on each side, and disposed rendering a neutral line of said permanent magnets identical to the center line of said magnetic gap.

9. A D.C. reactor as cited in claim 7 or 8, wherein said core structure comprises an E-shaped core and an I-shaped core.

10. A D.C. reactor as cited in claim 7 or 8, wherein said core structure comprises a T-shaped core and a C-shaped core.

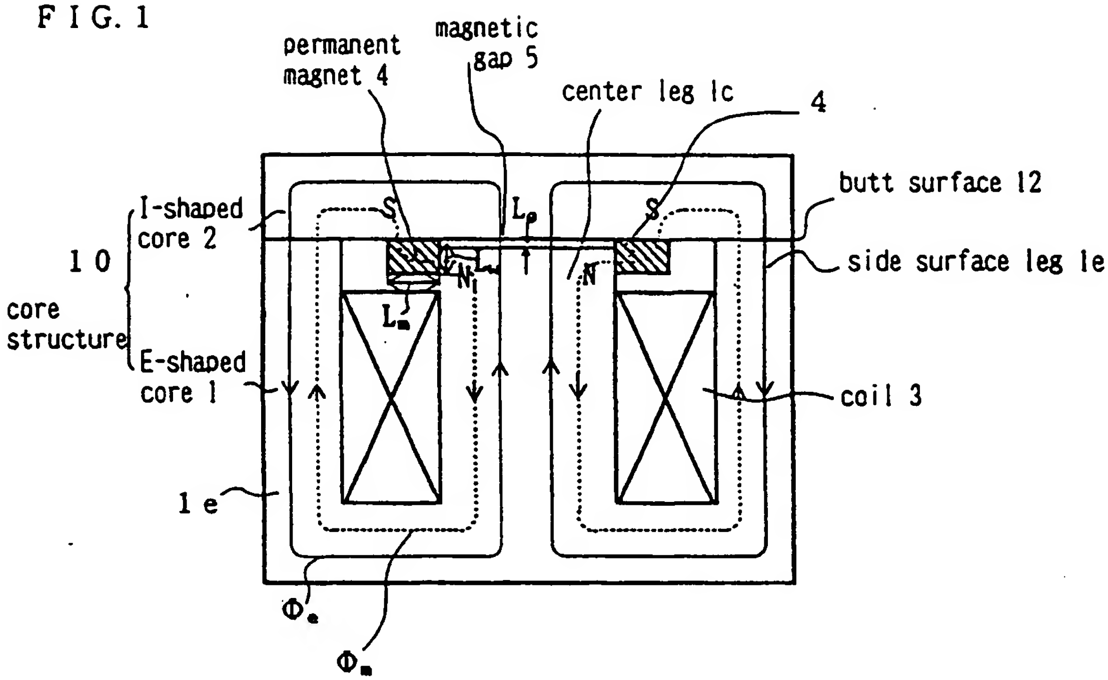
11. A D.C. reactor as cited in claim 7 or 8, wherein said core structure comprises an I-shaped core and a C-shaped core while causing said permanent magnets to have opposed portions of different polarity.

12. A D.C. reactor as cited in claim 7 or 8, wherein said core structure comprises a pair of C-shaped cores while causing said permanent magnets to have opposed portions of different polarity.

13. A D.C. reactor as cited in any one of the preceding claims 8 to 12, wherein each said core has projections on both side surfaces thereof with each said permanent magnet being inserted between a corresponding combination of projections.

14. A D.C. reactor as cited in any one the preceding claims 8 to 13, wherein each said permanent magnet has two pieces placed together while causing butt planes of respective pieces to have differing polarities.

F I G. 1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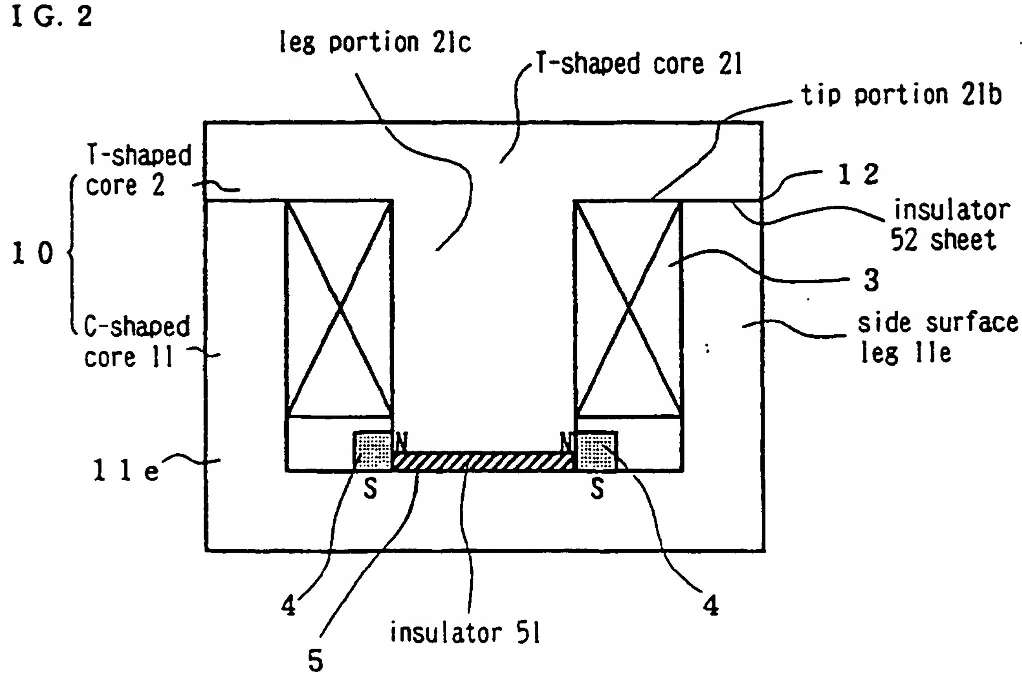
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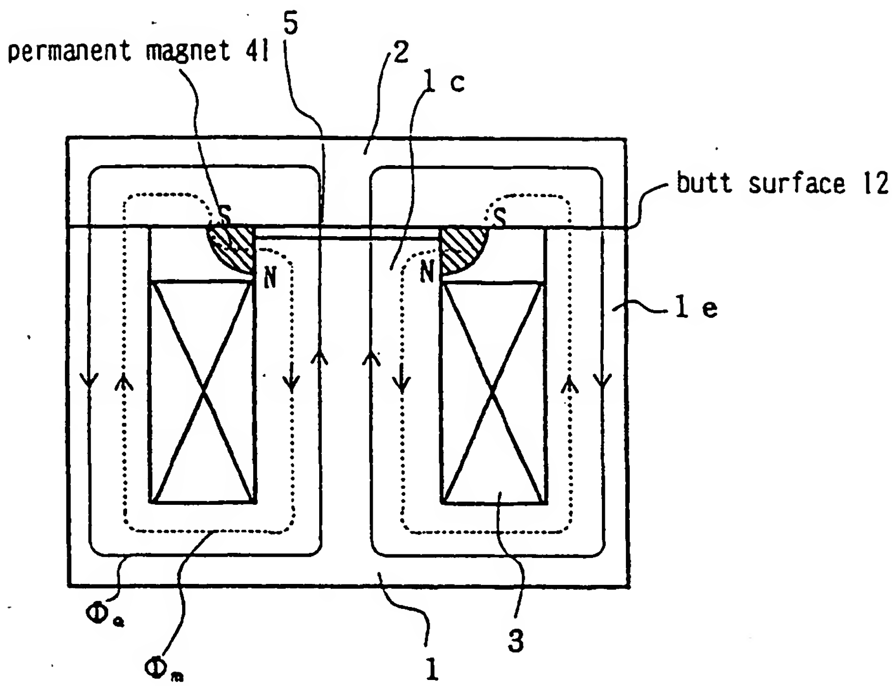
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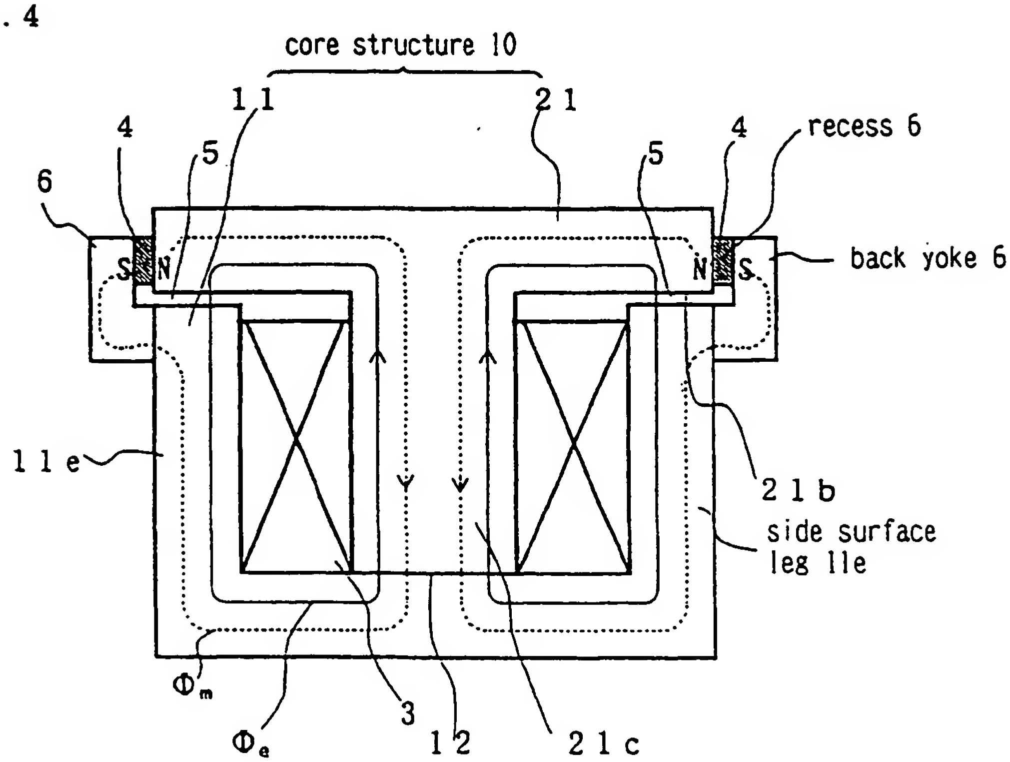
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FIG. 5

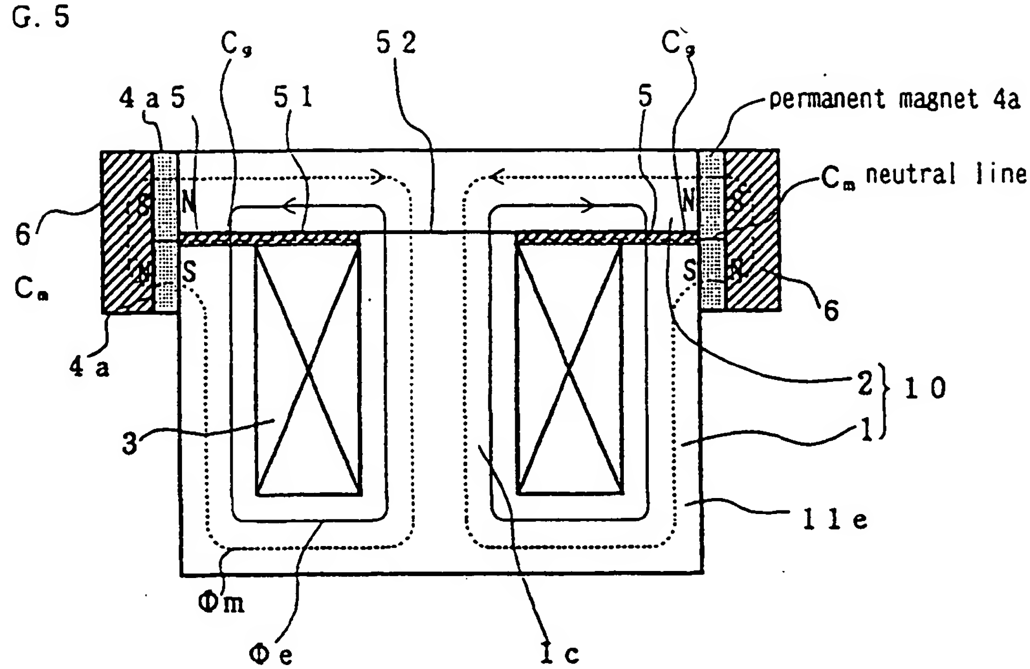
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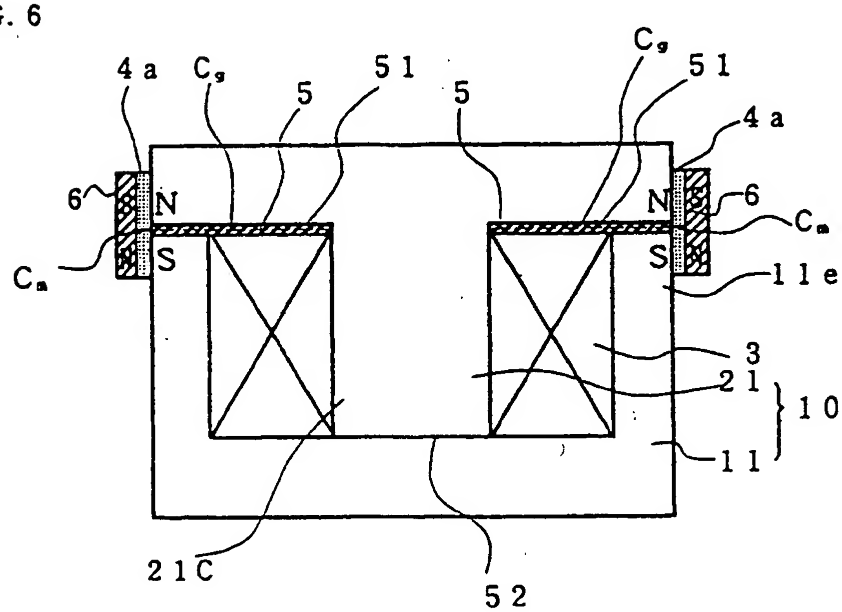
FIG. 6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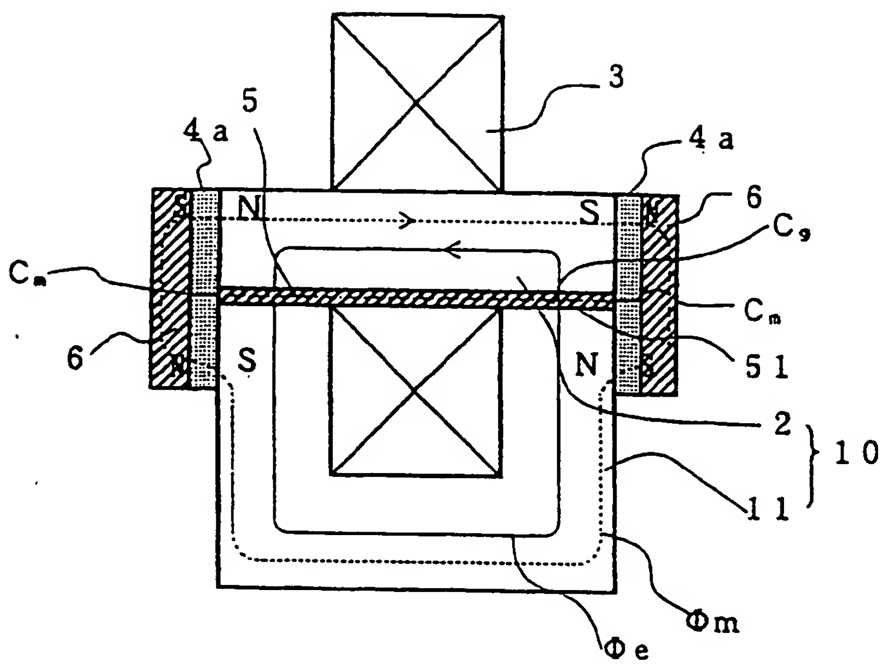
F I G. 7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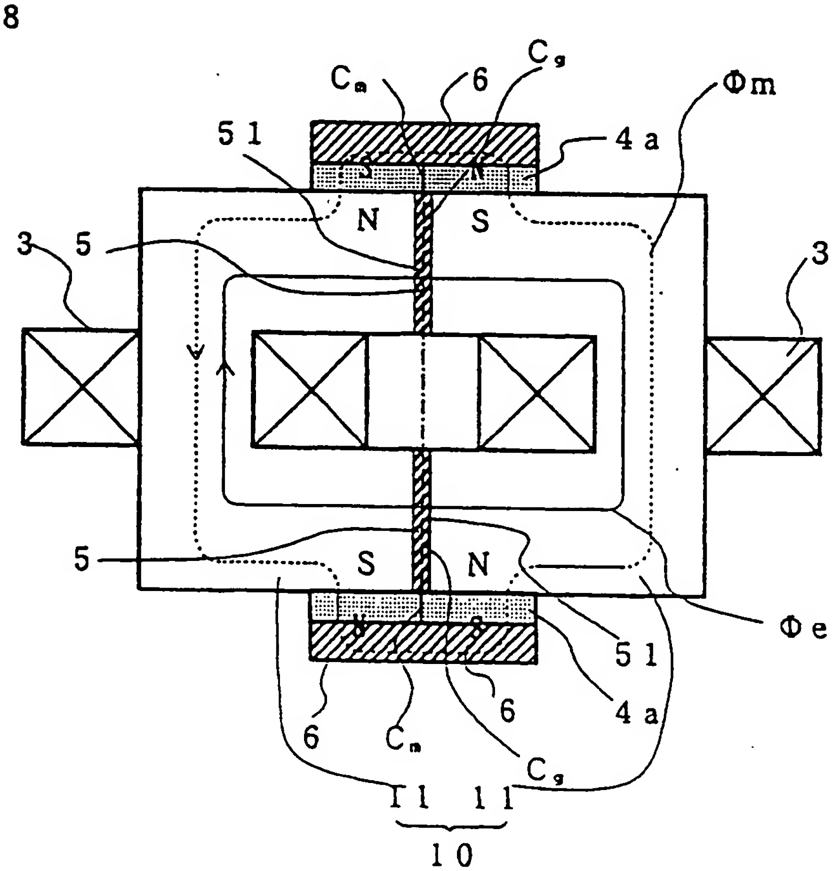
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C_m
6
Φm
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S
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S
3
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3
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Φe
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6
6
4 a
C_m
C_g
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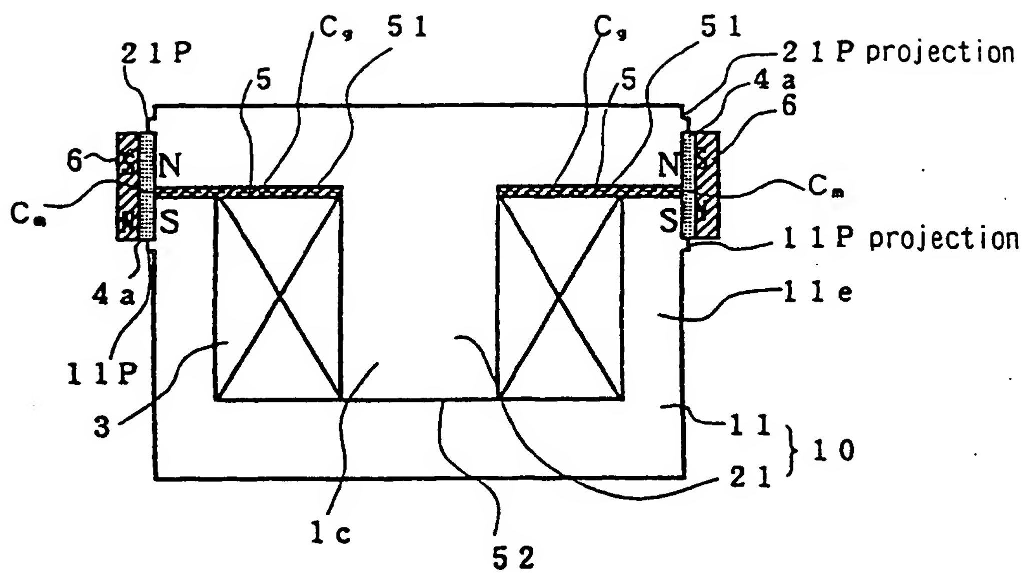
1 1
1 0

F I G. 9



Cg
5 1
Cg
5 1
2 1 P
2 1 P projection
5
5
4 a
6
6
N
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Cm
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S
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1 1 P projection
4 a
1 1 e
1 1 P
3
1 1
1 0
2 1
1 c
5 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP95/02508

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl^6 H01F27/24, 37/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl^6 H01F27/24, 37/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Kokai Jitsuyo Shinan Koho 1971 - 1996

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP, 54-152957, U (TDK Corp.), October 24, 1979 (24. 10. 79), Claim, Fig. 2 (Family: none)	1, 2, 6-8
Y	JP, 54-152957, U (TDK Corp.), October 24, 1979 (24. 10. 79), Claim, Fig. 2 (Family: none)	9 - 12
Y	JP, 57-96512, A (Hitachi Metals, Ltd.), June 15, 1982 (15. 06. 82), Claim, Fig. 1 (Family: none)	9 - 12
Y	JP, 46-37128, B1 (Toshiba Corp.), November 1, 1971 (01. 11. 71), Line 35, column 2 to line 16, column 3, Fig. 3a	9 - 12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
April 2, 1996 (02. 04. 96)	April 16, 1996 (16. 04. 96)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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